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THE TOOTHED BIRDS OF KANSAS

Odontornithes: a Monograph of the Extinct Toothed Birds of North America. By Prof. O. C. Marsh, Yale College. Vol. I. of Memoirs of the Peabody Museum of Yale College, New Haven, Conn., and Vol. VII. of the Geological Exploration of the 40th Parallel.

WEST from the valley of the Mississippi the stratified formations which underlie the prairie region spread over thousands of square miles nearly as horizontal as when they were deposited. Here and there they have been ridged up into anticlines, now deeply trenched by denuding agents, or have had wedges of the ancient Archæan rocks thrust through them, along the flanks of which their upturned beds can be examined in detail. Hence in spite of their prevalent flatness opportunities are afforded for tracing their stratigraphical succession from top to bottom. They reach a maximum of thickness of some seven or eight miles. Yet throughout this vast depth of strata the unconformabilities seem to be nearly all of local and unimportant character. The several geological systems follow each other continuously, and generally in such a sequence of insensible gradation as to show that geological history in that part of the globe was marked by comparatively few great and destructive geographical revolutions. The record of this history remains in an almost unbroken series of strata from the Primordial zones up into the older Tertiary formations.

Here surely if anywhere in the world there should be a tolerably ample chronicle of the sequence of living creatures, so far at least as regards marine forms. If the intermediate types, so much desired by the evolutionist, are ever to be found imbedded in the rocks of the earth's crust, surely here we may expect to find them. An area of continuous tranquil deposit, and of slow subsidence, unaffected for almost the whole of geological time by serious upheaval, metamorphism, or unconformability, containing within itself a well-nigh unbroken record of geological changes—a very promised land for the palæontologist! Hardly more than a dozen years have passed since this great region began to be systematically searched for organic remains. Yet during that brief period what treasures have come from its teeming strata! New orders of Vertebrates, some of them of extraordinary types, have thence been added to the long roll of organic forms. Other orders, scantily developed in Europe, and previously but little known, have been ascertained to have teemed in these far western plains. Whether we regard the prodigious number of individual specimens, and the great variety of genera and species, or the marvellously perfect state of preservation in which the remains occur, there is no other known area where facilities for palæontological research of the most minute and thorough kind exist so abundantly.

Thanks to the labours, first of the universally-honoured Joseph Leidy, and then of his younger successors, Marsh and Cope, the firstfruits of that rich palæontological harvest have already been gathered In the Yale College Museum alone about 1,000 new species of extinct Vertebrates have been received from the West during the past twelve years, at least one-half of which remain to be investigated. Mr. Cope's museum at Philadelphia is likewise crowded with new forms. If such results have been achieved merely by expeditions equipped for at most but a few months of such labour as is possible at present in these wilds, what may not be looked for when some of the habitable portions of the fossiliferous regions come to be searched, when quarries, railway cuttings, and other artificial openings add to the opportunities of exploring the rocks, and when systematic fossil-hunting can be carried on from a near centre of supplies, instead of from a base several thousand miles away in the Eastern States!

Among the organic wonders of which from time to time during the past decade announcements have appeared, none have been received with more interest than the discovery of birds with teeth, made by Prof. Marsh near the end of the year 1870, in the middle Cretaceous rocks, which in Kansas and Colorado spread out eastward from the base of the Rocky Mountains. The more striking features of this remarkable transitional ornithic type were described by Mr. Marsh as far back as 1872, and are now tolerably familiar to naturalists from his writings, and to geologists from the descriptions and restorations which have appeared in scientific journals and text-books. But its detailed structure has only now been made known in the splendid monograph on Odontornithes which has just appeared. This work is intended to form volume vii. of the Geological Exploration of the 40th Parallel, carried out by Mr. Clarence King for the Engineer Department, and also to stand as the first of a series of memoirs of the Peabody Museum of Yale College. As a fitting termination to the noble Survey series of quartos, and as a splendid forerunner for what we hope will prove a long and illustrious series of memoirs from Yale, the volume is doubly welcome. The splendour of paper, printing, drawing, and engraving (and in the advanced copy with which we have been favoured, the sumptuousness of binding) that have been lavished on the work bespeak preliminary acknowledgment.

So perfect a matrix do the peculiar buff, chalky, or marly beds of the Kansas middle Cretaceous formations furnish for the preservation of organic remains, that almost every bone of the skeletons of some of the birds has been recovered. The materials for the study of their osteology is thus almost as ample as that for any living bird. Full advantage of this abundant store of material has been taken. The cases and cellars in the Peabody Museum at New Haven contain the remains of about fifty different individuals of a single bird. Every bone of its skeleton, with the exception of one or two terminal toe-bones and the extreme point of the tail, has been recovered, and is here carefully drawn of the natural size. Never before has it been possible, we believe, to reconstruct so perfectly so ancient an organism.

The volume is divided into two parts. In the first of these the detailed structure is given of the bird on which the author has bestowed the name of *Hesperornis*. The skeleton of this animal if extended to its full length would measure about six feet from the point of the bill to the end of the tail. It must have been a typical aquatic bird, without any power of flight, but with strongly developed limbs and a long flexible neck, whereby it was doubtless endowed with remarkable powers of diving and swimming,

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and of seizing the abundant fishes of the shallow seas in which it lived. Compared with our modern birds, the two features of this ancient form which most forcibly arrest attention are the teeth and the legs. The teeth were covered with smooth enamel, terminating upward in conical pointed crowns and downward in stout fangs, closely resembling those of mosasauroid reptiles. Their mode of growth and replacement have been determined to have taken place in a manner very similar to that in some reptiles, the young tooth forming on the inner side of the fang of the tooth in use, and increasing in size, while a pit for its reception was gradually made by absorption. The old tooth, being progressively undermined, was finally expelled by its successor, the number of teeth thus remaining unchanged. The teeth were implanted in a common alveolar groove, as in *Ichthyosaurus*. In the upper jaw they were confined to the maxillary and entirely absent from the pre-maxillary bone; in the lower jaw they extended from near the anterior extremity of the ramus along the entire upper border of the dentary bone. Mr. Marsh believes that they were held in position by cartilage which permitted some fore and aft movement, but on the decay of which after death the teeth readily became displaced and fell out of the jaw. This is an important fact in its bearing upon the nature of the teeth found on the same slab of Solenhofen limestone with the well-known *Archæopteryx*. These teeth, it will be remembered, were referred by Mr. Evans to the bird itself—a reference fully confirmed by Mr. Marsh, who says that he at once identified the teeth as those of birds and not of fishes, and by the subsequent discovery of other remains of the bird. In *Hesperornis regalis* there appear to have been fourteen functional teeth in the maxillary bone and thirty-three teeth in the corresponding ramus of the lower jaw. The wings are rudimentary or aborted, a remnant of the humerus alone existing. They may have gradually diminished from disuse until, as the power of flight ceased, the legs and feet increased in proportion, and assumed the massive dimensions shown in the specimens, or, as Mr. Marsh suggests, the bird may have been a carnivorous aquatic ostrich, never having possessed the power of flight, but descended from a reptilian ancestry which is strongly recalled by different portions of the skeleton. Among recent birds, the peculiar legs and feet of *Hesperornis* find their nearest analogues in the Grebes of the genus *Podiceps*. They were admirably adapted for propulsion in water, but scarcely served for walking on land. Locomotion must have been entirely performed by the posterior limbs—a peculiarity which distinguishes *Hesperornis* from all other birds recent or fossil. The tail appears to have been composed of twelve vertebræ, unique in their peculiar widely extended transverse processes and depressed horizontal ploughshare bone. Broad and flat, somewhat like that of the beaver, it must have been a powerful instrument in steering the bird through the water.

The second part is devoted to a description of the remains which have been found of birds belonging to a second order of Odontornithes, termed *Odontotormæ*. Unlike *Hesperornis*, they seem to have been all of comparatively small size and to have possessed powerful wings, but very small legs and feet. From that contemporaneous form, and from all other known birds recent and fossil, they are distinguished by certain types of structure which point back to a very lowly ancestry, lower even than the reptile. Their bones, being mostly air-filled, would enable the carcases to float on water until, by decay or the rapacity of other animals, they were separated and dispersed. Hence skeletons of these flying birds are less entire than those of the massive-boned *Hesperornis*. Nevertheless the remains of no fewer than seventy-seven different individuals have been disinterred. These are included in two well-marked genera, *Ichthyornis* and *Apatornis*, and were all small birds, reminding us by their strong wings and delicate legs and feet of the Terns, like which they were probably also aquatic in habit. Besides the reptilian skull and teeth, the birds of this second order were marked by the character of their vertebræ, which in their biconcave structure recall those of fishes. This is the more remarkable, as in *Hesperornis* the vertebræ are like those of modern birds. Yet these two utterly dissimilar types were contemporaries, and their remains have been preserved in the same strata. Mr. Marsh points out that the transition between the two vertebral types may be traced even in the skeleton of *Ichthyornis* itself, where the third cervical vertebra presents a modification in which the ordinary avian saddle-shaped form appears as it were in the act of development from the biconcave ichthyic form.

In a concluding chapter the author briefly touches upon some of the broader biological questions suggested by the structure of the animals described in the volume. The striking differences between the three orders into which Prof. Marsh divides toothed birds—*Archæopteryx*, *Hesperornis*, and *Ichthyornis*—serve to indicate the high antiquity of the class, and to encourage the search for ornithic remains in the earlier Secondary, if not in the later Palæozoic, rocks. The peculiar character of each of the orders Prof. Marsh believes to have been united in some earlier type, of which no trace has yet been found. This ancestral type may have been almost as much a reptile as a bird. The earliest birds were doubtless closely related to the Dinosaurs and Pterodactyles.

Of the plates, thirty-four in number, which accompany and adorn the monograph it is impossible to speak in terms of too great praise. They are strictly and rigidly scientific diagrams, wherein every bone and part of a bone is made to stand out so clearly that it would not be difficult to mould a good model of the skeleton from the plates alone. And yet with this faithfulness to the chief aim of the illustrations there is combined an artistic finish which has made each plate a kind of finished picture. We heartily congratulate the genial Professor of Palæontology at Yale on the advent of this truly imperial volume. May it be the earnest of many more from the rich store of materials which he has so courageously and enthusiastically gathered among the wilds of the far West!

THE THEORY OF DETERMINANTS

A Treatise on the Theory of Determinants and their Applications in Analysis and Geometry. By Robert Forsyth Scott, M.A. (Cambridge: At the University Press.)

THE list of English text-books on the subject of Determinants is comparatively meagre, and this notwithstanding the fact that the first separate treatise of all

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